NUCLEAR ENERGY RESEARCH INITIATIVE

Improving Corrosion Behavior in SCWR, LFR, and VHTR Reactor Materials by Formation of a Stable Oxide

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Collaborators: Westinghouse Electric Company

Project Number: 06-100

Program Area: Generation IV

Project Description

This project is designed to establish a technical basis for corrosion protection of candidate materials for three different types of reactors: the supercritical water reactor (SCWR), the lead-fast reactor (LFR), and the very high temperature reactor (VHTR). The materials to be studied include ferritic-martensitic steels, austenitic alloys, and Ni-based alloys. In order to understand the mechanisms associated with corrosion behavior in these materials, a systematic study will be conducted on the nature of protective films formed during corrosion tests in simulated reactor environments. The overall objective is to understand why certain alloys exhibit better corrosion behavior than others by examining the oxide microstructure. Alloys that resist corrosion develop a protective oxide layer that limits the access of corrosive species to the underlying metal, leading to stable oxide growth. The differences between a protective and a non-protective oxide are determined by the alloy chemistry and microstructure. Very small changes in microstructure can significantly affect corrosion rate.

The techniques to be used are microbeam synchrotron radiation diffraction and fluorescence and cross-sectional transmission electron microcopy on samples prepared using a focused ion beam. Examination by x-ray diffraction and fluorescence resolves the crystal structure, texture, and composition of oxide layers at the sub-micron level. By complementing the examination with transmission electron microscopy, we will determine precisely the structure of these layers and their impact on corrosion behavior of the alloys.

Workscope

The following tasks comprise the primary project workscope:

- Procure initial set of alloy oxides
  - Obtain oxide samples and characterize base alloy microstructure
- Oxide characterization
  - Prepare samples for characterization
  - Conduct basic characterization, followed by TEM and synchrotron microbeam
- Data reduction and analysis
  - Identify oxide phases and determine elemental distribution
  - Compare oxide characteristics of as-fabricated and surface-modified alloys
  - Compare oxides formed in different environments